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SWINE BREEDING RESEARCH

at the Regional Swine Breeding Laboratory

Miscellaneous Publication No. 523

UNITED STATES DEPARTMENT OF AGRICULTURE

MISCELLANEOUS PUBLICATION NO. 523

Washington, D. C. July 1943

SWINE BREEDING RESEARCH AT THE REGIONAL SWINE BREEDING LABORATORY

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In cooperation with the agricultural experiment stations of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oklakoma, South Dakota, and Wisconsin

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INTRODUCTION

The high cost of farm animals and the slow rate of reproduction have been major obstacles in their experimental breeding. In these respects, however, hogs have advantages over the larger animals. Furthermore, their importance in the farm enterprise makes it particularly desirable to improve their utility characters. Cooperative effort between State experiment stations and the United States Department of Agriculture seems to offer a means of approach to the problem.

Consideration of these points led to the establishment of the Regional Swine Breeding Laboratory by Congress through the Bankhead-Jones Act. Research to be undertaken was outlined by representatives of the State experiment stations in the Corn Belt and the United States Department of Agriculture. The laboratory was established in 1937 with headquarters at Ames, Iowa.

OBJECTIVE OF THE LABORATORY

The principal objective of the laboratory is to discover, develop, and test procedures of breeding that will result in improvement of

[1] Acknowledgment is made to project leaders in the laboratory for assistance in preparing this report. The author is particularly indebted, for helpful suggestions, to Jay L. Lush, L. M. Winters, L. J. Cole, Ralph Bogart, and M. L. Baker, and also to Hugh C. McPhee, assistant chief of the Bureau of Animal Industry, who are serving as a committee on publications.

swine. The following four phases of study are involved: Systems of breeding, measures or standards of appraising hogs and their carcasses, heritability of various characters, and physiology of reproduction. Emphasis is being placed on productiveness of sows, growth rate of pigs, economy of gains, vitality, and desirability of carcasses.

GENERAL PROCEDURE

A promising supplement to conventional breeding practices that is being studied at the laboratory is the development of inbred lines combined with selection for productiveness of individual animals. This permits selection from different lines of breeding, use of inbred boars for top crossing on noninbred stock, and hybridizing inbred lines within and between breeds. Inbreeding to some degree is necessary to form distinctly different lines of stock, especially within breeds; it expedites the forming of lines that differ widely in their heredity. Production recording is being practiced as it helps in locating not only the superior lines but also the individuals and litters within lines that have the best heredity.

The different phases of the investigations are being pursued through projects in progress at 7 State experiment stations (Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, and Oklahoma). In 1942 three other State stations in the region (Ohio, South Dakota, and Wisconsin), initiated projects that are coordinated closely with the basic project. Work of the laboratory is coordinated through an annual conference of representatives of each of the State stations and the Department. General supervision and final coordination are accomplished through a director.

FACILITIES, EQUIPMENT, AND PERSONNEL

The land, permanent buildings, and animals required for investigations are provided by the cooperating State stations. Technical personnel, clerical help, labor, and movable equipment needed in the various projects are provided jointly by the cooperating agencies and located at the laboratory headquarters at Ames, Iowa, and at various cooperating State experiment stations. Approximately 900 acres of land and 1,000 breeding animals are being used in the projects of the laboratory and those projects coordinated closely with it.

RESULTS [2]

Systems of Breeding

Inbred lines are being developed within 5 breeds and 2 crossbred foundations in these experiments. There are 40 of these lines, and the average inbreeding varies from about 10 to 70 percent. Figures 1 to 4 show several of these lines. The cover page shows Chester White gilts of an inbred line at the Wisconsin station. In general, 3 different intensities of inbreeding are being investigated in lines all of which are closed to outside blood: (1) Those in which 1 boar per generation

[2] Detailed results in tabular and graphic form are given in published reports of a number of investigators connected with the laboratory or the cooperating State stations. These reports are in large measure the basis of results included in this publication and are referred to throughout the text.

is used, (2) those in which 2 boars per generation are used, and (3) those in which 3 to 5 boars per generation are used. Inbreeding increases about 12 to 14 percent per generation in 1-sire lines, 6 to 7 percent in 2-sire lines, 3 to 4 percent in 4-sire lines, and less rapidly if more than 4 sires per generation are used. Increases in inbreeding

FIGURE 1.—Poland China gilts of inbred lines at the Iowa station.

are measured as percentages of the inheritance that was unfixed (heterozygous) in the parents but theoretically becomes fixed (homozygous) in the offspring. For example, one-generation half-brother × half-sister = 12.5-percent inbreeding; one-generation brother × sister = 25-percent inbreeding.

FIGURE 2.—Poland China gilts of an inbred line at the Missouri station.

In these experiments about half of the lines with only 1 sire per generation have performed well, whereas the other half have done poorly. The latter have been generally low in fertility, vitality, or rate of growth. About two-thirds of the lines with 2 sires per generation have performed satisfactorily. One line in which four boars per generation have been used since 1930 is in the project at the Iowa

station. The performance of this line has been similar to that of non-inbred stock. Persistent effort has been made to select for good performance and individual excellence in all lines, and results have been in close agreement with genetic expectation.

FIGURE 3.—Duroc-Jersey gilts of an inbred line at the Nebraska station.

In general, there has been a slight decrease in fertility, vitality, and rate of growth as inbreeding has advanced. But in some lines these traits have been maintained at approximately their original level, and

FIGURE 4.—A mixed group of hogs of the cross line Danish Landrace-Tamworth at the Minnesota station.

other traits—for example, types of feet and legs and economy of gains—have been improved. Most lines that performed well at the beginning have continued to do so. In the good lines the decline in fertility, vitality, and rate of growth has not been enough to be serious.

The offspring resulting from crossing 2 inbred lines have shown an increased rate of growth and an increased vitality varying from very slight to marked. As would be expected, the most marked increases have occurred in crosses of widely unrelated lines. Inbred boars used by farmers have produced favorable results, but there are not yet enough data on these to permit a definite comparison of lines or of inbred boars with noninbred boars. Extensive trials are necessary for proper evaluation of the lines and top crosses, as shown by Dickerson (*6*)[3] and Comstock and Winters (*3*).

Records on a cross line developed at the Minnesota station from crossing the Danish Landrace and Tamworth breeds have been studied and reported by Winters and coworkers (*22*). The performance of this herd has been good. Fertility, vitality, rate of growth, and economy of gain have been exceptionally good. These hogs are about 1½ inches longer in the body and 2 inches shorter of leg than those of most American breeds. They are also high in quality of carcasses produced. The results demonstrate that crossing two established breeds can provide a good foundation for the development of an inbred line.

Another cross line has been begun at the Indiana station. It involves the Duroc-Jersey and Danish Landrace breeds and is now in the second generation.

In general the data, considered collectively from all projects, permit 2 conclusions with respect to inbred lines: (1) Stock with low fertility, low vitality, or a low rate of growth in the first generation of inbreeding respond slowly if at all to selection for improvement in these traits; and (2) genetically good stock may be inbred 5 to 10 times as fast as has been practiced in the pure breeds without serious loss of practical individual merit. A herd closed to outside blood, in which 3 to 5 boars per generation are used, increases in inbreeding at about this rate.

Previously reported studies of swine pedigrees made by Lush and Anderson (*13*) of the Iowa station indicate that, as a result of inbreeding, genetic purity of the pure breeds has increased about 0.5 percent per generation since the breeds were established. Accordingly, stock available in the pure breeds are inbred approximately 10 to 12 percent. Thus the original unfixed characters of the foundation stock of the oldest pure breeds have become fixed as a result of inbreeding to the extent of only 10 to 12 percent since the breeds originated. If the use of inbred lines should become a desirable procedure in improving breeds or in commercial pork production, it is important to know the most efficient way to produce such lines with the least loss of individual merit in the stock. These studies of systems of breeding will furnish information on the usefulness and limitations of inbred lines.

Measures or Standards for Appraising Hogs and Their Carcasses

Value of farrowing and weaning records in selecting sows

While the projects were getting under way, a study of certain data available at the cooperating stations was made. The object of the study was to appraise the value of farrowing and weaning records in selecting sows. The results are reported by Lush and Mollu (*14*).

[3] Numbers in parentheses refer to Literature Cited, p. 13.

The records had been kept in experiment station and college herds of 8 States and in the herds maintained by the Bureau of Animal Industry for experimental purposes. Most of the data were obtained from the middle 1920's to the spring of 1937. Data included 7,415 litters for number of pigs farrowed and 2,144 litters for number of pigs weighed at weaning time. It is believed that the conclusions reached apply generally to both purebred herds and well-managed commercial herds of hogs. Three points having an important bearing on breeding swine for larger litters were derived from the study:

(1) Repeatability, or successive production of sows for number and weight of pigs weaned per litter, is about one-sixth. Therefore, in selecting sows for number of pigs farrowed and for weight of litters at weaning one could expect to gain about one-sixth of the increase aimed at. Sows that produce first litters above the average in number of pigs farrowed may be expected, in their later litters, to produce about 0.31 pig more than the entire group of sows from which they are selected will produce.

(2) Accuracy of selection for number of pigs farrowed and weaned and for weight at weaning can be increased materially if selection is based on averages of 2 or more litters. The same percentage of culling of sows will make the increase in the productivity of the herd about 31 percent larger if culling is based on averages of 2 litters than if it is based on only 1 litter for each sow. Selection based on 3 litters will produce about 50 percent more increase than if it is based on 1 litter only. But retaining sows for 3 litters will decrease the number of generations that can be bred within a given time without increasing the size of the herd.

(3) Progress from selecting for productivity can be made somewhat more rapidly if selections are based in part on the average performance of close relatives, such as full sisters and dams. But if these are overemphasized, rate of progress will be decreased, since for estimating a sow's productive ability her own record is approximately three times as important as that of her dam or of a full sister.

Performance of sows at the Missouri station, as reported by Weaver and Bogart (*19*), emphasize the importance of the results of the study by Lush and Molln. For litters of 4 pigs, the feed required per 100 pounds of live hogs marketed was 571 pounds; for litters of 7 pigs, 448 pounds; and for litters of 10 pigs, only 341 pounds.

These studies bear out the fact that number and weight of pigs raised are the most precise measures of sow productivity that have been used. However, differences between the real abilities of sows account for only about one-sixth of the variations observed in the litters. Thus genetic improvement in productivity of sows will be slow, but it should be steady, on the average, if sow testing is done with care. Therefore, one should make full use of the records on productivity in selecting breeding animals.

SELECTION INDEXES AND PROGENY TESTS

An index as a measure of productivity of sows that has been worked out and is being tested at the Iowa station is described by Lush and Molln (*14, pp. 26–28*). Each item in an index may be weighted according to how well it is believed to indicate the practical usefulness

or breeding value of the animal. The productivity index now being used includes the following 5 items, each being weighted to give them about equal importance: Number of pigs farrowed, number of pigs alive at 3 weeks, number of pigs alive at 8 weeks, total weight of the litter at 3 weeks, and total weight of the litter at 8 weeks. It seems unlikely that weights at both 3 and 8 weeks are necessary, but the evidence as to which is the better measure of the sow's productivity is not yet conclusive.

Hazel and Lush (*10*, *11*) developed a selection index that is being tested at the Iowa station for selecting boars and gilts. The index is based on 180-day weight, individual score at 225 pounds of weight, and productivity of the dam. Theoretically, selections based on this index are 38.5 percent as efficient as if the actual genotypes of the animals were known. Inclusion of records on brothers and sisters increases efficiency of the index by about 2 percent. Selections based on score alone are about 14 percent as accurate as if the genotypes were known. Thus the use of a rather simple index may be much more efficient than selecting on a basis of individual appearance alone.

Progeny testing as a means of measuring the performance of breeding animals has been studied by Dickerson and Hazel (*7*). The following points in this study are of special interest:

(1) Total improvement in a herd for a given period depends not only on improvement made per generation but also on the average interval between generations. Progress in a herd will be increased if records on individual performance and on pedigree and performance of relatives are used in such a way as to keep the interval between generations as short as practicable.

(2) The possibility of accelerating rate of improvement by using progeny-test information depends mainly on the opportunity for culling before progeny records can be ready, type of characters in which improvement is desired, heritability of the characters, and rate of reproduction. For a character such as growth rate in swine, which can be observed in both sexes rather early in life, and with heritability of about 30 percent, increases in accuracy of selections from progeny testing of boars do not appear to be sufficient to justify the increase in time required between generations. But for traits such as desirability of carcasses, which cannot be measured on the breeding animals themselves, the only basis for first cullings is the average performance of close relatives. Accordingly, progeny testing may be necessary to effect much improvement in carcass characters. For other characters having low heritability, perhaps 20 percent or less, progeny testing may increase progress considerably or may even be necessary to insure any progress. The study indicates that in selection for carcass traits, approximately 10 percent more progress is to be expected when about one-fourth of the sows are saved for second litters than when all sows are replaced annually with gilts.

In a further study of the usefulness of progeny records for selecting breeding stock, growth rate and productivity combined were investigated by Dickerson and Hazel (*8*). The conclusions indicate that in selecting for growth rate of pigs and productivity of sows best results should be obtained over a long period of time by saving one-third to one-half of the gilts for a second year on the basis

of their first litters. But rate of improvement in these 2 traits should be only a little less than maximum when cullings are based on individual 180-day weight and the dam's productivity, and all breeding animals are replaced annually. The effect of culling boars at weaning age when selecting for growth rate and productivity was examined. At least one-third of the boar pigs should be saved at weaning to provide sufficient opportunity for further culling at a later date when growth rates are more clearly evident. Progress in selecting for growth rate and productivity falls off rapidly when fewer than one-sixth of the boar pigs are kept after weaning. If final selections of all boars are made when they are 56 days old, progress will be 40 percent below the maximum. This means that about 10 times as many boars should be saved in early culling as are finally to be used.

These investigations emphasize the necessity for production records on whole herds if much improvement is to be made in selecting for such traits as productivity of sows and growth rate of pigs. Records are needed on the litters as to number of pigs raised and weights of the pigs at some time between 112 and 180 days of age if maximum progress is desired.

EFFECT OF FEEDING PRACTICES AND SEX OF ANIMALS

The importance of feeding practices with pigs on measures for selecting breeding stock has been studied at the Minnesota station by Comstock et al. (*5*). They suggested that if unequal nutrition of pigs prior to weaning could be corrected by a suitable method of supplementary feeding during the suckling period, effectiveness of selection on a basis of weaning weights and also of 180-day weights would be increased. Furthermore, they concluded that, with present feeding methods, measures of growth from weaning to marketing will be more useful in selecting for growth rate in hogs than measures of growth involving the entire period from birth to marketing. Further study of the latter question is needed to determine how much might be gained by basing selections for growth rate on growth from weaning rather than on growth from birth to 120, 150, or 180 days of age.

Differences in growth rate between barrows and gilts have been investigated in studies relating to new standards for selection. In Poland China inbred lines at the Minnesota station, barrows exceeded gilts about 2.5 percent in rate of growth to about 200 pounds of weight, according to Comstock, Winters, and Cummings (*4*). In the oldest Poland China line at the Iowa station, as shown by Whatley (*20*), the rate of growth of boars and barrows together was about 4 percent higher than that of gilts to 180 days of age. Data on lines of other breeds reveal differences of 1 to 5.5 percent in favor of boars and barrows. The significance of these differences in respect to standards for selecting breeding stock is not yet clear.

ECONOMY OF GAIN AND PRODUCTIVITY

In the development of new measures or standards of appraising hogs, a scoring plan is being tried. When the animals are 200 or more pounds in weight, they are scored on the following points:

(1) Health and vigor, as expressed by general appearance and factors indicating thriftiness; (2) quality, as expressed by fineness of hair and bone, general smoothness of skin, trimness of jowl, and trimness of shoulder and middle; (3) length of body as estimated from base of tail to a point between the ears; (4) details of conformation, including all points as to body form, feet, and legs; (5) animal as a whole, including all points covered in other items and, in addition, color, type, symmetry, and breed characteristics; and (6) market grade, based on degree of fatness, smoothness, and firmness, involving Choice, Good, Medium, and Cull grades as used on the hog markets.

Each item ranges in score from 0 to 9, the latter being a perfect score. Thus 54 would be a perfect score for an individual animal. It was planned to score the pigs when they weighed approximately 225 pounds, but this procedure has not been possible. For most pigs the scoring weight is about 210 to 240 pounds. It varies more in some projects than in others. The relation between scores and weight of pigs when scored has been investigated at the Iowa station and is reported by Mollin (*16*). As a rule the heaviest pigs at scoring time receive the highest scores not only for market grade but also for other items. The scores studied at the Iowa station also appear to be related to weight at 180 days of age as shown by Mollin (*15*).

Studies involving scores of live hogs and of carcasses by project leaders of the Iowa, Missouri, Nebraska, and Oklahoma stations show that these scores are correlated but the relationship is too low to have a high predictive value. In both live-hog and carcass scores, however, a fairly high correlation has been found among the following items: Length of body, plumpness of hams, and degree of finish.

CARCASS STUDIES

Carcass studies vary among the cooperating stations, depending on facilities available. These are most complete at the Iowa, Missouri, Nebraska, and Oklahoma stations. Where facilities permit, two or more pigs from the litters of the various lines that have been fed under standard conditions are slaughtered at 225 pounds of weight. The carcasses are scored, measured, and in some cases cut.

In general, the carcasses from well-finished hogs in all lines have been satisfactory to packer buyers and carcass graders. There has been, however, some variation in grade, score, and items measured both between lines and within lines. But commercial and hereditary significance of these differences has not been established. The results, however, together with results of hog-carcass studies reported in the literature, suggest the following considerations for carcasses from 225-pound hogs: (1) Carcasses should be 30 to 31 inches long from aitchbone to first rib; (2) 1.2 to 1.5 inches of back fat is sufficient to insure a reasonable degree of firmness and cuts without excessive fatness when hogs are fed properly; (3) more lean in proportion to fat than is being yielded by American breeds of hogs is desirable.

Hogs that meet the first 2 points have approximately the following live-hog measurements: (1) 40 to 42 inches in length diagonally along the side from base of tail to a point between the ears, (2) 14 to 15 inches in depth back of shoulders, and (3) 11 to 12 inches in width back of shoulders. These hogs are of the type called inter-

mediate by breeders and hog judges in the Corn Belt. Until a more suitable measure is found, these figures may serve as a quantitative standard for such hogs weighing 225 pounds.

Heritability of Various Characters

GROWTH RATE

An intensive study of early data at the Iowa station relating to heritability of growth rate has been reported by Whatley (*20*). He concluded that not less than 30 percent and perhaps more than 40 percent of the variations in 180-day weights of pigs are hereditary.

Rate of growth in pigs at the Nebraska station by 56-day periods—birth to weaning, weaning to 112 days, and 112 to 168 days—has been reported by Baker and associates (*1*). Heritability of gain from 56 to 112 days of age—28 percent in the Nebraska data—seems to be almost twice as high as from birth to weaning and about the same as from birth to 168 days of age. If further studies confirm this observation, it will have practical implications, since it is desirable to select boars before "ranting" begins, which ranges in general from 120 to 150 days of age. Studies previously noted by Dickerson and Hazel (*8*) emphasized the advantages of retaining at least one-third of all boars until some time beyond weaning age before making selections. In the Minnesota project boars have slightly exceeded their barrow brothers in rate of growth until the onset of sexual maturity, according to Winters and coworkers (*23*). In general the onset of sexual maturity in boars varies from about 120 to 180 days of age. Thus the extra increase in weight may compensate in part for postponing castration of boar pigs until they are 4 or 5 months old.

One project has been initiated to test the effectiveness of selecting for rate of growth, when selections are based entirely on this trait, and to study in more detail the heritability of growth rate. This experiment is in progress at the Illinois station with 2 lines closed to outside blood. About 5 boars are used in each line for each generation so that inbreeding will increase very slowly. Accordingly, any decline in rate of growth within the lines due to inbreeding should be negligible.

In 1 line at the Illinois station the most rapid-gaining animals are selected to become parents of the next generation; in the other line the slowest-gaining animals are chosen to produce the next generation. Three generations of pigs have been produced in the project. It appears that the lines are separating in rate of growth, but the experiment is still incomplete and the early indications need verifying. However, the rapid-gaining line at present is closer to the medium type, the modern ideal in respect to type, than the slow-gaining line.

ECONOMY OF GAIN AND PRODUCTIVITY

Data are being taken on economy of gain at each of the cooperating stations. These are being studied, but conclusions are incomplete as to heritability and the effectiveness of selection for economy of gain in the inbred lines.

The heritability of the sow-productivity index proposed by Lush and Molln has been estimated to be about 16 percent, as reported by Hazel [4]. Although Hazel's estimate is based on only a moderate amount of data, his conclusion agrees closely with the estimate of successive production (one-sixth), found by Lush and Molln. The similarity of the two findings tends to increase one's confidence in their validity and general applicability.

CONFORMATION

An estimate of the heritability of conformation as evaluated by the live-hog scores at the Iowa station has been reported by Stonaker and Lush (*18*). They concluded that about 20 percent of the variation in total score is heritable. Analysis, made by Whatley and Nelson (*21*), of scores on hogs in the project at the Oklahoma station suggests that heritability of differences in scores may exceed 20 percent. Therefore, the general conclusion that differences in scores are about one-fifth heritable is believed to be justified.

DEFECTS

One rather serious defect, hemophilia, that occurred in a line at the Missouri station has been studied, as to its nature and inheritance, by Bogart and Muhrer (*2*) and Hogan and coworkers (*12*). Hemophilia has occurred in man for a long time and is known as a sex-linked recessive in respect to its inheritance. As far as the author is aware, a similar condition in swine has not been reported in the literature, although it has been reported by hog breeders to the project leaders at the Missouri station. Afflicted animals, when injured either externally or internally, bleed to death. The deficiency first becomes apparent when pigs are about 2 months of age, but it is variable in this respect and also in its severity. It is concluded that hemophilia in swine is due to an autosomal recessive gene and that the variation between individuals in the severity of the abnormality is caused by modifying genes.

Other defects of swine which have occurred in some lines have been described and recorded, but the data available do not permit analysis of the details of their inheritance. These defects include hernia, cryptorchidism, blindness, crooked-legs, flatfoot, screw-tail, defective bone development, cleft palate, earlessness, atresia ani, and swirled hair.

Physiology of Reproduction

Two questions relating to physiology of reproduction have been investigated briefly. The first relates to differences in the amount of androgenic substances secreted in the urine of boars; the second, to chemical tests for pregnancy in sows.

Variations were observed in the amount of androgen excreted by individual boars within and between different lines of breeding at the Minnesota station, as reported by Green, Winters, Rash, and Dailey (*9*). The importance of the differences and their relationship to fertility of boars were not determined.

[4] Hazel, L. N. Principles of a selection index which involves several characteristics and utilizes information concerning relatives. Iowa State College, Ames, Iowa. 1941. [Unpublished thesis.]

A chemical test for pregnancy in sows, described by Roth and associates (*17*), has been developed at the Missouri station. This test permits reasonably accurate diagnosis of pregnancy from the twenty-first to thirty-second day after breeding. Such tests are useful in experimental work and may become useful for determining pregnancy of sows to be listed in sales.

SUMMARY AND CONCLUSIONS

For the purpose of discovering, developing, and testing procedures of breeding that will result in improvement of swine, the Regional Swine Breeding Laboratory was established in 1937 with headquarters at Ames, Iowa. Investigations are coordinated and carried on cooperatively between the United States Department of Agriculture and the agricultural experiment stations of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, and Wisconsin.

The experiments initiated relate mainly to systems of breeding. Inbred lines are being formed within pure breeds and from crossbred foundations. The 40 lines already formed range from about 10 to 70 percent in inbreeding.

In general there has been a slight decrease in fertility, vitality, and rate of growth as inbreeding has advanced. In the better lines, however, the decline noted has not been enough to be serious. In some lines these traits have remained at the level shown by the foundation stock, and other traits—economy of gain, for example—have improved. In genetically good stock the rate of inbreeding can be increased at least 5 to 10 times as fast as that being practiced by breeders of the pure breeds without serious loss of individual merit.

Preliminary trials of inbred boars on noninbred sows and of crosses of inbred lines have mostly produced good results. Pigs from crosses of widely unrelated inbred lines have shown an increase in vitality and rate of growth, but increases have varied for the different crosses.

Attention also has been given to a study of measures or standards of appraising hogs and their carcasses. An index measuring the productivity of sows has been developed and is being tested. It appears to be fairly effective but needs further testing before it can be recommended for general use. Performance of sows, measured by number of pigs weaned and weaning weights of litters, apparently is about one-sixth heritable.

In selecting for growth rate of pigs and productivity of sows, best results should be obtained over a long period of time by saving one-third to one-half of the gilts for a second year on the basis of their first litters

Scores for hogs based on items of conformation, quality, and degree of fatness at market weight are less reliable in selection than weight at 180 days of age. Variations in weight at 180 days of age have proved to be approximately one-third heritable, whereas variations in scores seem to be about one-fifth heritable.

In general, carcasses from well-finished hogs in all inbred lines have been satisfactory to packers and carcass graders. There has been, however, some variation in grade, score, and items measured both between lines and within lines. Commercial and hereditary significance of

these differences has not been established. However, results in general show that carcasses from 225-pound hogs should be 30 to 31 inches long from aitchbone to first rib, that 1.2 to 1.5 inches of back fat insures a reasonable degree of firmness, and that more lean in proportion to fat than is being obtained from American breeds of hogs is desirable.

Hemophilia has been studied in one inbred line. The data indicate that this affliction in swine is due to an autosomal recessive gene and that the variation between individuals in the severity of the abnormality is caused by modifying genes.

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